[encode] encoding target pixel value x. If the flag f(-merr(S)) is "1", the prediction value correction circuit 405 adds the mean value merr(S) to the prediction value p outputted by the predictor 404, and outputs the obtained value as a corrected prediction value p'=p+merr(S). In this case, the mean value merr(S) may be controlled to have positive value.

On the other hand, if the mean value f(-merr(S)) is "0", the prediction value correction circuit 405 outputs the prediction value p as it is, as the corrected prediction value p'. The subtracter 409 obtains the prediction error e=x-p' between the [encode] encoding target pixel x and the corrected prediction value p', and then outputs the obtained prediction error e.

A subtracter 412 obtains and outputs the prediction error e2 which is the difference between the [encode] encoding target pixel x and the prediction value p. The inspection circuit 411 checks the flag value f(e2) corresponding to the differential value e2. Then, if the flag value f(e2) is "0", the circuit 411 rewrites it into "1".

The prediction value correction circuit 405 performs increment on the number N(S) of the prediction error e for each context S, newly adds the prediction error e generated by the subtracter 409 to the cumulative value E(S) and stores the obtained value. The Huffman table generator 406 counts the number of generation of the prediction error e for each context S which is derived from the context generator 403.

By repeatedly performing the above-described process for all the image data inputted from the signal line 401, nine frequency distributions each corresponding to each context S are generated in the internal memory of the Huffman table generator 406. In this case, the nine Huffman tables are structured respectively from these nine frequency distributions and then stored in the Huffman table memory 407.

In the second path, the nine Huffman tables stored in the memory 407 are appropriately switched and used for each context S, whereby the encoding and outputting are performed.

When the above-described process is terminated, the next image data beginning from the first pixel is again sequentially inputted into the signal line 401, and the prediction error e is generated for each pixel in the same operation as that in the first path. The Huffman encoder 408 performs the Huffman encoding on the prediction error e by referring to the Huffman table corresponding to each context S stored in the Huffman table memory 407, and outputs the obtained data.

The above-described process is repeatedly performed for the entire encoding target pixels, and thus the [encode] encoding data is outputted.

The present invention is not restricted to the above-described embodiments. For example, as the prediction method of the encoding target pixel value, the pre-predicting may be simply used. On the other hand, by providing the several prediction methods, these methods may be appropriately switched or exchanged.

Further, in the above-described embodiments, the Huffman encoding and the Golomb-Rice encoding are used as the encoding means, but another encoding such as the arithmetic encoding or the like may be used.

It will be obviously understood that the object of the present invention can be achieved by supplying a storage medium in which program codes of a software to realize the functions of the above-described embodiments are stored to a system or an apparatus, and reading and executing the program codes stored in the storage medium with a computer (CPU or MPU) in the system or the apparatus.

In such a case, the program codes themselves of the software read out of the storage medium realize the functions of the above-described embodiments, thus the storage medium in which the program codes have been stored construct the present invention.

As such the storage medium to store the program codes, e.g., it is possible to use a floppy disk, a hard disk, an optical disk, an optomagnetic disk, a CD-ROM, a CD-R, a magnetic tape, a non-volatile memory card, a ROM or the like can be used.

Further, it will be obviously understood that the present invention incorporates not only a case where the functions of the above-described embodiments are realized by executing the program codes read by the computer, but also a case where an OS (operating system) or the like operating in the computer performs a part or all of the actual processes on the basis of instructions of the read program codes and by such [the] processes the functions of the above-described embodiments are realized.

Furthermore, it will be obviously understood that the present invention also incorporates a case where the program codes read out of the storage medium are written into a memory provided for a function expansion board of the computer or a function expansion unit connected to the computer and, after that, the CPU or the like provided for the function expansion board or the function expansion unit executes a part or all of the actual processes on the basis of instructions of the program codes, and the functions of the above-described embodiments are realized by the processes.

As explained above, in the case where the image to be encoded consists of the discrete pixel values, the image encoding apparatus according to the present invention performs the controlling such that the correction of the prediction value by the prediction value correction means is not performed. Therefore, even in the case of encoding the data of the image such as the CG image, the limited-color image or the like having the discrete pixel value, the encoding can be effectively performed by utilizing bias of the prediction error.

Many modifications and variations are possible for the present invention, within the spirit and scope of the appended claims.

What is claimed is:

1. An image encoding apparatus, comprising:

generating means for generating a first prediction error difference on the basis of a first value of at least one reference pixel and a first prediction value of the reference pixel, and generating a second prediction error difference on the basis of a second value of an encoding target pixel and a second prediction value of the encoding target pixel, the reference pixel being encoded before the encoding target pixel is encoded and the first prediction error difference being generated before the second prediction error difference is generated;

judging means for judging an appearing prediction error difference and an unappearing prediction error difference on the basis of the first prediction error difference, [and for encoding the second prediction error difference on the basis of the judged appearing and unappearing prediction error differences,] wherein the second prediction error difference is not used in the judging operation;

changing means for changing a first corresponding relationship between prediction error difference and encoding data to a second corresponding relationship between prediction error difference and encoding data according to a result obtained by said judging means; and

encoding means for encoding the second prediction error difference on the basis of [a selected] one of the first and second corresponding relationships to obtain corresponding encoding data.

2. An apparatus according to claim 1, wherein the first and second corresponding relationships are each a respective corresponding relationship between the prediction error difference and variable length encoding data, and wherein said encoding means executes variable length encoding on the second prediction error difference.

3. An apparatus according to claim 1, wherein said encoding means encodes the first prediction error difference before encoding the second prediction error difference.

4. An apparatus according to claim 1, wherein said encoding means executes Huffman coding.

5. An apparatus according to claim 1, wherein said encoding means executes Golomb-Rice encoding.

6. An apparatus according to claim 1, further comprising prediction means for generating the second prediction value of the encoding target pixel on the basis of a peripheral pixel of the encoding target pixel.

7. An image encoding method, comprising the steps of:

generating a first prediction error difference on the basis of a first value of at least one reference pixel and a first prediction value of the reference pixel, and generating a second prediction error difference on the basis of a second value of an encoding target pixel and a second prediction value of the encoding target pixel, the reference pixel being encoded before the encoding target pixel is encoded and the first prediction error difference being generated before the second prediction error difference is generated;

judging an appearing prediction error difference and an unappearing prediction error difference on the basis of the first prediction error difference, [and for encoding the second prediction error difference on the basis of the judged appearing and unappearing prediction error differences,] wherein the second prediction error difference is not used in the judging operation;

changing a first relationship between prediction error difference and encoding data to a second corresponding relationship between prediction error difference and encoding data according to a result obtained in said judging step; and

encoding the second prediction error difference on the basis of [a selected] one of the first and second corresponding relationships to obtain corresponding encoding data.

8. A computer readable storage medium that stores program codes for executing an image encoding method, said method comprising the steps of:

generating a first prediction error difference on the basis of a first value of at least one reference pixel and a first prediction value of the reference pixel, and generating a second prediction error difference on the basis of a second value of an encoding target pixel and a second prediction value of the encoding target pixel, the reference pixel being encoded before the encoding target pixel is encoded and the first prediction error difference being generated before the second prediction error difference is generated;

judging an appearing prediction error difference and an unappearing prediction error difference on the basis of the first prediction error difference, [and for encoding the second prediction error difference on the basis of the judged appearing and unappearing prediction error differences,] wherein the second prediction error difference is not used in the judging operation;

changing a first relationship between prediction error difference and encoding data to a second corresponding relationship between prediction error difference and encoding data according to a result obtained in said judging step; and

encoding the second prediction error difference on the basis of [a selected] one of the first and second corresponding relationships to obtain corresponding encoding data.

9. An image encoding apparatus comprising:

generating means for generating a prediction value of an encoding target pixel;

prediction value correcting means for correcting the prediction value;

judging means for judging whether or not each of pixels of a reference area is represented by part of one of a plurality of total available values, wherein the encoding target pixel is not involved in the judging operation, and each pixel of the reference area is encoded before the encoding target pixel is encoded; and

control means for controlling the correcting operation by said prediction value correcting means in accordance with a result by said judging means.

10. An apparatus according to claim 9, wherein said control means controls said prediction value correcting means to leave the prediction value unchanged when each reference pixel is represented by the part.

11. An apparatus according to claim 9, further comprising entropy encoding means for generating a prediction error difference on the basis of a value of the encoding target pixel and a prediction value generated by said generating means, said entropy encoding means encoding the prediction error difference.

12. An image encoding method comprising the steps of:

generating a prediction value of an encoding target pixel;

correcting the prediction value;

judging whether or not each of pixels of a reference area is represented by a part of one of a plurality of total available values, wherein the encoding target pixel is not involved in the judging operation, and each pixel of the reference area is encoded before the encoding target pixel is encoded; and

controlling the correcting operation in said correcting step in accordance with a result in said judging step.

13. A computer readable storage medium that stores program codes for executing an image encoding method, said method comprising the steps of:

generating a prediction value of an encoding target pixel;

correcting the prediction value;

judging whether or not each of pixels of a reference area is represented by part of one of a plurality of total available values, wherein the encoding target pixel is not involved in the judging operation, and each pixel of the reference area is encoded before the encoding target pixel is encoded; and

controlling the correcting operation in said correcting step in accordance with a result in said judging step.